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APPLICATION FOR UNITED STATES LETTERS PATENT

FOR

ELECTRICAL CONTACTOR WITH POSITIVE TEMPERATURE COEFFICIENT RESISTIVITY ELEMENT

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BACKGROUND OF THE INVENTION

Field of the Inv ntion

The present invention relates generally to an apparatus with a plurality of contacts for connecting and disconnecting an electrical power source to an electrical device while suppressing transient energy between the plurality of contacts and more particularly to an electrical contactor electrically coupled to a positive temperature coefficient resistivity (PTC) element for reducing arcing between the electrical contactor's contacts.

Description of the Related Art

Figures 1(a) and **1(b)** illustrate a prior art electrical contactor **10**, which is commonly used as a control device for various types of motors. The contactor **10** has a yoke **12**, comprising a ferromagnetic material, and at least one coil **14**, which is positioned in at least one opening in yoke **12**. An armature **16**, also comprising a ferromagnetic material, is positioned atop yoke **12** and can be manipulated by at least one coil **14**, as discussed below.

Two pairs of contacts **18, 20** and **22, 24** are typically used in electrical contactor **10**. Contacts **18, 22** are stationary, with contact **18** mounted on line terminal **26** and contact **22** mounted on load terminal **28**. Contacts **20, 24** are mounted on blade **30**, which moves in tandem with armature **16**. Armature **16** and

blade **30** are affixed to a shaft or carrier **32**, having a distal end and a proximal end, and comprising a nonconductive material, for example, a thermoplastic. Carrier **32** may contain a recess for receipt of a compression spring **34**, which is used to ensure contact between contacts **18**, **20**, **22** and **24**. The electrical contactor **10** contains additional components which are well known in the art and, therefore, these components have not been discussed for the sake of simplicity.

Figure 1(a) illustrates an electrical contactor **10** in an "open" or non-conducting position. In the open position, no current flows though coil **14**. Subsequently, there is no electromagnetic force interacting with armature **16**.

As current flows through coil **14**, an electromagnetic force is generated which attracts armature **16**. Armature **16** is pulled toward yoke **12** and coil **14** by the electromagnetic force, which causes carrier **32** and blade **30** to move toward yoke **12** and coil **14**. As the armature **16**, carrier **32** and blade **30** move toward the yoke **12** and coil **14**, moveable contact **20** contacts stationary contact **18** and moveable contact **24** contacts stationary contact **22**, as illustrated in **Figure 1(b)**. Contact between the two pairs of contacts **18**, **20**, **22** and **24** is substantially simultaneous. As discussed above, compression spring **34** places a sufficient force on carrier **32** to ensure that moveable contacts **20**, **24** contact stationary contacts **18**, **22**, respectively, when current flows though coil **14**.

Upon termination or interruption of current flow in coil **14** and removal of the electromagnetic force, armature **16**, carrier **32** and blade **30** move away from yoke

12 and coil **14** and moveable contacts **20**, **24** separate from stationary contacts **18**, **22**, respectively, as illustrated in **FIGURE 1(a)**.

There are several disadvantages with use of the prior art electrical contactor **10**. Arching may occur when contacts **18**, **20**, **22** and **24** close and separate, thereby gradually eroding away the contacts. Severe arc erosion commonly occurs during motor startup or interruption of a locked motor. Typically, existing electrical contactors are limited to a maximum of approximately 9,000 operation cycles under such severe conditions because the electrical contactors have to make or interrupt approximately 6 times the contactor's continuous current rating.

Another disadvantage of the prior art is contact welding. With the existence of high currents during startup of a motor or interruption of a locked motor, contacts **18**, **20**, **22** and **24** are prone to become welded together resulting in a permanent closed circuit. Welding of the contacts **18**, **20**, **22** and **24** may lead an operator to abuse the on/off mechanism and/or contactor case, further damaging the device in an attempt to force open the contacts of the electrical contactor **10**. Additionally, the welds may be broken by operation of the contactor following a welding of the contacts. In this case, severe pitting may exist in the vicinity of the broken weld. This may lead to improper contact engagement during future operations resulting in a high resistance contact, which may further lead to decreased contact life, additional welding or a runaway thermal condition. Clearly, once contact welding occurs, the electrical contactor will fail to function properly.

In an attempt to reduce the possibility of arc welding of the contacts, silver/cadmium oxide contacts are commonly used. Cadmium is a harmful element to human beings and the United States Environmental Protection Agency (EPA) has expressed concern about the use of silver/cadmium oxide contacts. Therefore, an alternative to the use of silver/cadmium oxide contacts is desirable.

Thus there is a need for a simple electrical contactor which overcomes the foregoing disadvantages of the prior art by providing a positive temperature coefficient resistivity element electrically coupled or connected to a plurality of contacts in the electrical contactor to suppress transient energy between the contacts.

SUMMARY OF THE INVENTION

A preferred embodiment of the present invention features an electrical contactor for connecting and disconnecting an electrical power source to an electrical device wherein the electrical power source is electrically connected to a line terminal having a line terminal electrical contact and the electrical device is electrically connected to a load terminal electrical contact.

In the preferred embodiment, an electromagnetic element is electrically coupled to the electrical power source for generation of a magnetic field. Upon generation of the magnetic field, a slidable carrier, having an armature affixed to a distal end and an asymmetrical blade affixed to a proximal end is attracted to the electromagnetic element. The blade has a plurality of electrical contacts wherein

one electrical contact is aligned with the line terminal contact and a second electrical contact is aligned with the load terminal contact. The contacts electrically connect the electrical power source to the electrical device upon generation of the magnetic field and disconnect the power source from the electrical device upon removal of the magnetic field. A positive temperature coefficient resistivity element is electrically coupled to the blade and the load terminal for providing arc suppression during the opening and closing of the electrical contacts.

In an alternative embodiment, the electrical contacts on the blade, which is symmetrical, are aligned with a stationary electrical contact and the load terminal electrical contact. The line terminal is physically and electrically separate from the stationary electrical contact. However, a connector electrically connects the line terminal to the blade. The electrical contacts electrically connect the electrical power source to the electrical device upon generation of a magnetic field and electrically disconnect the electrical power source to the electrical device upon removal of the magnetic field. The positive temperature coefficient resistivity element is electrically coupled to the stationary electrical contact and the load terminal electrical contact for providing arc suppression during the opening and closing of the electrical contacts.

In yet another embodiment, a spring strap having an electrical contact replaces the stationary electrical contact. The spring strap propels an electrical contact, affixed to it, upwardly thereby providing sequential contact between the contacts with the spring strap electrical contact and a blade electrical contact closing prior to the load terminal electrical contact and the second blade electrical

contact. The positive temperature coefficient resistivity element is electrically coupled to the spring strap electrical contact and the load terminal electrical contact for providing arc suppression during the opening and closing of the contacts.

Examples of the more important features of the invention thus have been summarized rather broadly in order that the detailed description thereof that follows may be better understood, and in order that the contributions to the art may be appreciated. There are, of course, additional features of the invention that will be described hereinafter and which will form the subject of the claims appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

For detailed understanding of the present invention, references should be made to the following detailed description of the preferred embodiment, taken in conjunction with the accompanying drawings, in which like elements have been given like numerals and wherein:

FIGURE 1a illustrates a prior art electrical contactor with contacts in an "open" or non-contact position;

FIGURE 1b illustrates the prior art electrical contactor of **FIGURE 1a** with contacts in a "closed" or contact position;

FIGURE 2 illustrates an electrical contactor having an asymmetrical blade for sequential opening and closing of contacts and a PTC element used in the suppression of transient energy between contacts of the electrical contactor in accordance with a preferred form of the present invention;

FIGURE 3 illustrates an alternative embodiment of the present invention wherein a stationary electrical contact is employed in the sequential opening and closing of the contacts and a PTC element is used in the suppression of transient energy between contacts of the electrical contactor; and

FIGURE 4 illustrates an alternative embodiment of the present invention wherein a symmetrical blade and spring strap, having an electrical contact, allow for sequential opening and closing of the contacts and a PTC element is used in the suppression of transient energy between contacts of the electrical contactor.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention relates to an electrical contactor having a positive temperature coefficient resistivity (PTC) element for suppressing transient energy, typically arcing. The PTC element can comprise a pure metallic material, such as pure tungsten or pure iron, a conductive polymer or ceramic PTC material. The PTC element suppresses any arc that may occur between the electrical contacts of

the contactor. A certain amount of the interruption energy is converted into heat energy in the PTC element. As a result of the reduction of contact arcing, the erosion of the electrical contacts is dramatically reduced and contact welding is eliminated. Therefore, the present invention increases the life and continuous current rating of the electrical contactor.

FIGURE 2 illustrates a preferred embodiment of the present invention wherein a PTC element **36** is electrically connected in parallel with contacts **22, 24**. A flexible conductor **38** may be affixed to blade **30** and used to connect PTC element **36** to electrical contactor **10** or PTC element **36** may be wired directly to blade **30** and load terminal **28**. Blade **30** is asymmetrical to ensure a sequential connection/separation of the two sets of contacts **18, 20** and **22, 24**. Both sets of contacts **18**, **20** and **22**, **24** are connected in series, carry current under normal operating conditions and contribute to the total contact resistance. Contact resistance is a major cause of thermal increase in electrical contactor **10** at full continuous current rating. Therefore, the higher the contact resistance, the lower the continuous current rating and vice versa.

As current flows through coil **14**, an electromagnetic force is created which attracts armature **16**. Armature **16** is pulled toward yoke **12** and coil **14** by the electromagnetic force, which also causes carrier **32** and blade **30** to move toward yoke **12** and coil **14**. As the armature **16**, carrier **32** and blade **30** move toward the yoke **12** and coil **14**, moveable contact **20** contacts stationary contact **18** and moveable contact **24** contacts stationary contact **22**.

Contacts **18**, **20** make contact before contacts **22**, **24** as a result of the asymmetrical blade **30**. When contact is made between contacts **18**, **20** electrical current flows though contacts **18**, **20** the PTC element **36**. There is less arcing between contacts **18**, **20** compared to the prior art electrical connector **10** in **FIGURE 1**, because the PTC element **36** limits current flow during the closing of contacts **18**, **20**. Any arc between contacts **22**, **24** is also suppressed during the connection of the contacts because of the parallel PTC element **36**.

When the electrical contactor **10** is utilized to interrupt current, current is removed from coil **14**, thereby removing the electromagnetic field, and armature **16** is release from the coil **14** and yoke **12**. Contacts **22**, **24** open prior to contacts **18**, **20** because of the asymmetrical shape of blade **30**. Once contacts **22**, **24** are opened, current is shunted to the PTC element **36** and any arc between contacts **22**, **24** is suppressed. As a current limiting device, the PTC element **36** also suppresses the arc between contacts **18**, **20** following the separation of contacts **22**, **24**.

FIGURE 3 illustrates an alternative embodiment of the present invention. A connector **40**, preferably a thick braid connector, is connected in parallel with contacts **18**, **20** and in series with contacts **22**, **24**. Line terminal **26** is physically and electrically separate from stationary contact **18**. PTC element **36** is connected in parallel with contacts **22**, **24** and in series with contacts **18**, **20**. Under normal operating conditions when contacts **18**, **20**, **22** and **24** are closed, a substantial portion of current flows through connector **40** and contacts **22**, **24**. Very little current

flows through contacts **18**, **20** since the resistance of the PTC element **36** is substantially larger than the contact resistance of either set of contacts. The total contact resistance of the electrical contactor **10** illustrated in **FIGURE 3** is approximately half the total resistance of the electrical contactor in **FIGURE 2**. Therefore, the continuous current rating of the electrical contactor **10** in **FIGURE 3** is higher than that of the electrical contactor **10** in **FIGURE 2**. Additionally, contacts **18, 20** in electrical contactor **10** in **FIGURE 3** can be made smaller and from inexpensive material since the contacts **18, 20** do not have to continuously carry current.

The arc suppression effectiveness of the electrical contactor **10** in **FIGURE 3** is equivalent to the arc suppression effectiveness of the electrical contactor **10** in **FIGURE 2**. When the electrical contactor **10** in **FIGURE 3** opens, contacts **22, 24** open first because of the asymmetrical blade **30**. Since the current is shunted to pass through the PTC element **36** and contacts **18, 20**, the arc between contacts **22, 24** is suppressed. Contacts **18, 20** open after the PTC element **36** provides current limitation. As a result of the current limitation of PTC element **36**, any arc between contacts **18, 20** is also suppressed and the current is interrupted after the arc is extinguished between contacts **18, 20**.

When power is to be applied from the electrical power source to the electrical device, blade **30** is moved by the attraction of the armature **16** to the yoke **12** and coil **14**. In the sequential closing process, contacts **18, 20** close first followed by

closure of contacts **22**, **24**. In this manner, any arc between the contacts is suppressed due to PTC element **36**.

As can be seen above, by adding PTC element **36** to the electrical contactor **10** circuit, any arc between contacts **18**, **20**, **22** and **24** is effectively suppressed. There is no need to use silver/cadmium oxide contacts in electrical contactor **10**. Silver/tin oxide or silver/nickel contacts can be used with the present invention. The silver percentage at the contact surface can be increased with the present invention. The silver content makes the electrical contacts **18**, **20**, **22** and **24** soft and thus reduces the contact resistance. This helps to increase the continuous current rating of the electrical contactor.

FIGURE 4 illustrates an alternative embodiment which allows for sequential opening and closing of electrical contacts **18**, **20**, **22** and **24** with the use of a symmetrical blade **30**. The electrical contactor **10** in **FIGURE 4** uses an electrical contact **18** mounted on a spring strap **42**, which asserts an upward force on electrical contact **18** during the opening of electrical contacts **18**, **20**. The spring strap **42** places electrical contact **18** in close proximity to electrical contact **20**. Therefore, electrical contacts **18**, **20** open subsequent to the opening of electrical contacts **22**, **24**. During the closing of the electrical contacts **18**, **20**, **22** and **24**, electrical contacts **18**, **20** close prior to closure of electrical contacts **22**, **24** and spring strap **42** is lowered to a bottom position after electrical contacts **18**, **20**, **22** and **24** are closed.

The foregoing description is directed to particular embodiments of the present invention for the purpose of illustration and explanation. It will be apparent, however, to one skilled in the art that many modifications and changes to the embodiment set forth are possible without departing from the scope and the spirit of the invention. It is intended that the following claims be interpreted to embrace all such modifications and changes.